

268  
An

Inaugural Essay

on the

Vacuity of the Arteries

after

Death

Deposited March 13<sup>th</sup> 1827

W. & H.

by

Charles Nobles

of

Philadelphia

Submitted to the examination  
of the

Trustees and Faculty

of the

University of Pennsylvania

11 mo. 1826

The first  
to be  
and then  
In the  
the same  
date and  
the first  
the first  
of the  
of the  
the first  
the first

The Secrecy of the Arteries after death, is well known to practitioners of morbid anatomy, and to Medical Men generally; but no satisfactory explanation has yet been advanced of this phenomenon.

In speaking of his experiments, Dr. Harlan says "I now thought that the phenomenon in question was explained, by supposing the blood to circulate in the veins, whilst no man was propelled into the Arteries and arterial canals, the latter was of course unplied. — But I was soon convinced, that though the principal objection was obviated, the experiment did not explain in what manner that portion of blood forced into the aorta by the last contraction of the left ventricle, found its way independent of any 'vis a tergo' through the whole extent of the arterial canals to the mouths of the veins. This constitutes the problem to be solved; and it was of this in particular Dr. Myster asserted, he had

are here  
though I  
think of  
the subject  
and action  
the the p  
smashed  
into wine  
liberation

How  
to the Med  
might be el  
sunday be  
of persons  
As see  
for the Med  
to the Med  
one effo

"never heard any satisfactory explanation offered;  
 "although he had avoided himself of frequent offers  
 "of converse with men of science upon  
 "this subject; some of whom argued the pressure  
 "and action of surrounding muscles, as the cause;  
 "others the pressure of the external air; but he  
 "remarked the elasticity of the coats of the arteries  
 "could resist any such pressure and prevent the  
 "obstruction of their lumen." *Recher. Médec. 1769* p. 10.

How interesting to the Physiologist and  
 to the Medical Practitioner, this subject of itself  
 might be its importance is much increased when we  
 consider how closely it is connected with the subject  
 of venous circulation.

As various causes have been assigned as causes  
 for the blood flowing from the extreme arteries back  
 to the heart, it will be proper to mention them,  
 and ~~separately~~ to take them into consideration. X

My husband  
to the order  
of Henry  
as it is attested  
by  
in by Henry  
has circulated  
with that; one  
a result of the  
to have been  
in the form of  
the Power  
of the above power  
the society of the  
that this  
the character  
from the being

1st. By Richardson, Menes Circulation is ascribed chiefly to the contraction of the veins themselves.

2nd. By Harvey, by Majandis, and by Galenus & Zani, it is attributed to the action of the heart alone.

3rd. by Boerhaave and Boisson it is asserted, that Menes Circulation is owing to a vacuum formed in the Chest: and by the latter of the two, that the vacuity of the arteries after death depends on the same cause.

4th. While Boerhaave, Bichat, and some others place the force almost exclusively in the Capillaries.

Other Powers have also been assigned, in aid of these above mentioned, viz. the action of Muscles, the elasticity of the arteries &c.

That Vessels possess a contractile force is proved by their diminution in Caliber, when removed from the living body, as in the operations for

*[Faint, illegible handwriting on the left page of an open manuscript. The text appears to be a continuous paragraph or a list of entries, but the characters are too faded to transcribe accurately.]*

*[Faint, illegible handwriting on the right page of the manuscript. The text is partially visible and appears to be a continuation of the writing on the left page.]*



various pain; - by puncturing a vein between two ligatures; and by the superficial veins assuming different size, according as the surface is exposed to a warm or a cold atmosphere.

But this contractility is very little more than sufficient to accommodate them to the quantity of their contents, and is inferior in force to the power driving the blood on from behind, hence the distension of a vein on the application of a ligature, or on any other cause obstructing the course of the blood; and hence also the engorgement of the veins in death.

That the blood does not circulate in the veins by their contractility, may be seen by the following experiment.

That that part of a superficial vein on the arm or hand, where there is a space of one inch or more between two vessels without receiving any branch laterally; place one finger on the lower vessel, the vein then between the finger and the

of the river  
 then over  
 and ancient belt  
 which that  
 of the flood  
 clearly prints out  
 upon and under  
 is showing the  
 is a large  
 and is also  
 which. Niganda  
 find a ligature  
 with enclosing  
 supplied a lig  
 when making  
 and complex in  
 a way between  
 the four united

upper valve remains fast as before, which it would not do if the vein was the cause of the motion of the blood. Then with a second finger, force what blood remains between the first finger and the upper valve above that valve. The vein being empty below and the blood still remaining above the upper valve distinctly points out its situation. Lastly raise the finger, and instantly the agitated portion of blood falls, showing that the motion of the blood originates on a 'dis a loco'.

Work was shown by the following experiment  
related by Hajendie in his work on Physiology page 334  
to form a ligature around the thigh of a dog,  
without including the femoral artery or vein, and  
then applied a ligature to the femoral vein. The Green  
when working it, left openings into the vein the  
blood escaped to a considerable extent, and then passed  
the artery between his fingers, to prevent the arterial  
flow from reaching the members, the above said.



or by a line around the vent near some distance  
out on the surface, and also with a piece of wire  
the whole length of the line or some part of the whole  
embraced by a piece of wire, and a complete length  
the base of the line then applied: at this point  
the wire is to pass the wire, the line is drawn  
the heart is then cut over as it was inserted  
the first division, the line is then drawn at the  
opening of the vent, the first division is drawn  
till the wire is loose. It then separates the  
artery as a little it is as before and then is the  
arterial blood into it during the drawing of the line  
from the origin of the line back place but there  
was no jet till the artery was entirely free

In the attitude before mentioned to the  
heart, after examining around themselves: some  
connect with the propulsive action of the heart, the  
sustaining of the artery: Others say the heart acts



7  
on the one hand on a propelling power, on the other  
on an attracting by forming a vacuum by the  
dilatation of the right auricle.

It seems necessary the contraction of the left  
ventricle is to send the blood to the extremities  
arteries, yet that it is not necessary for arterial  
circulation is proved by that going on after  
the impulses of the heart has been cut off by a  
ligature or by pressures applied on an artery;  
the circulation thus goes on into the arteries  
having exhausted of their contents as in the case  
of a patient of Maygrier — Though Maygrier  
inferred that arterial circulation was owing  
to the propulsive action of the heart and the  
elasticity of the arteries, in reality he does  
not admit, but thinks a different reason  
might be put upon it, which will be men-  
tioned hereafter.

With the view to ascertain the truth in this





matter the following experiment was made by  
 myself with the assistance of a fellow student.  
 We confined a guinea pig on its back, with  
 the legs extended horizontally; an incision was  
 made into the abdomen, and a ligature drawn  
 tightly around the uterus near its base  
 above the bifurcation; the inferior vena was then  
 punctured with a lancet just below the ligature,  
 the blood flowed immediately and continued flow-  
 ing, as we judged, between 10 and 15 minutes.

In  $\frac{3}{4}$  of an hour from the application of the ligature  
 the animal being dead, the femoral and ilio-lum-  
 bar arteries were examined and found abso-  
 lutely empty, the corresponding veins were impregnated  
 with blood.

Inference. As the blood flowed from the  
 renal vena and the arteries became empty after  
 the impulse from the heart had run out off,  
 we must infer, there is a power independent



of the heart, capable of propelling the blood into  
and through the veins; ... and thus is the  
contractility of the veins, for the Femoral veins  
remained full although there was an outlet  
for the blood, by the opening in the inferior Cava.

That Venous Circulation depends on the heart  
is also contradicted by the following experiment  
abstracted from Spalanzani's work on the Cir-  
-culation page 359. "I placed (he says) a ligature  
"on the middle of the descending aorta of a Frog:  
"the portion below it and the heart increased in  
"capacity, and became a deeper red, whilst that  
"portion beneath the ligature was pale, and col-  
"lapsed, and although it retained only a small  
"quantity of blood, its diameter did not appear in  
"the least diminished."

That the heart attracts the blood by dilatation,  
and thus causes its motion in the veins, is contra-  
-dicted by the common operation of puncturing



by the experiment of Stojendie; and by that made  
 a vessel, in which a ligature was passed around  
 the neck. It is also contradicted by the numerous  
 previous experiments that takes place after death

The opinion of Carson to which much attention  
 has been paid, that the circulation of the blood in the  
 veins and that there is a vacuum is owing to the  
 tendency in the lungs to form a vacuum by their  
 elasticity, which in effect has the effect of drawing  
 the blood from the different parts of the body until  
 this vacuum is filled. To which account it is  
 the arteries are found empty after death, there not  
 being blood enough to fill both arteries and veins.

This opinion has already been reported in  
 the 5th vol. of the Philadelphia Medical Journal  
 by Stuart. who sent the circumstance of Dr. Carson's  
 repeated Carson's experiments with two entirely different  
 results.



Carum found some Trillids to open the thorax, the same as the process to be followed and the same as if any vessel to be distended. In these Trillids he found the muscles in sections in some cases, the transparent membrane which enclosed and the same developed. While in Trillids killed by fracturing the spinal marrow the muscles were white and dry the membrane not visible, and the same occurred.

But in the repetition of these experiments, not the least difference could be perceived in the whole circulation between animals killed in the two different ways except the lungs, these killed by dissection were of a lighter color and contained no blood; he found the venous system in general capable to contain the blood independent of the vacuum formed in the lungs.

But Carum has not shown that a vacuum really existed after death. And by the following experiment





extracted from Williams' paper on the distribution  
of the blood in the Lungs, in the 13th. No. of the Journal  
of Foreign Medical Sciences. We see that the respiration  
of the lungs and the right side of the heart  
may go on after the chest has been laid open and  
all vacuum of course destroyed.

The Animal was killed by severing the trachea  
at the acute of inspiration, and the sternum and  
costal cartilages ends of the ribs were removed in pres-  
ence of Dr. Hall. The blood in the pulmonary veins  
was observed to change its colour to a darker red as  
the current ceased. Immediately after the first stroke,  
the left ventricle felt contracted: then an irregular  
action of the muscular fibres of the right ventricle  
commenced which lasted for some time. Dr.  
Mistake, one of the branches of the pulmonary artery  
passing the right lung was divided instead of  
a branch of one of the pulmonary veins, which  
poured out blood copiously. As soon as the mistake



discovered, the student was clamped to the fingers  
of an assistant, who grasped the femoral artery. The  
right auricle and ventricle became greatly distended.

One of the pulmonary veins transverse the left  
lung was now punctured, and a small quantity  
only of blood oozed out. When the blood which had  
accumulated in the left auricle and ventricle  
was discharged by making a free opening into  
the former of the two cavities. After it was discharged  
no more blood flowed or oozed out of that opening,  
or from the puncture that was in the vein.

At the same time blood continued to stream  
freely from the system at large, to the right  
cavities of the heart. After a while the pulmonary  
artery was punctured, which was followed by a copious  
discharge of its contents. The windpipe was last  
divided and the lungs instantly collapsed, with  
incredible rapidity, until their vessels diminished  
in their bulk had taken places. It satisfied



ourselves that the vessel that bled so freely was a branch  
 "of the pulmonary artery, a probe was passed into it  
 "from the right ventricle. After the action of the  
 "heart had ceased we were much astonished  
 "at the vitality of the drops of blood, producing a  
 "badly the most perfect contraction of that muscle.  
 "all the others were at rest."

I in two cases, indeed, in a case of death, who  
 "should the blood from the the arteries, comes a  
 "circulation then, in order to enter our system in the  
 "heart. But I am not certain that a perfect  
 "circulation in the arteries after death is not impossible  
 "there are several parts the arteries that escape, from  
 "the blood are drawn into a mass, or well  
 "some other way; but as blood is not contained  
 "in the vessels about the same the blood would be  
 "inadequate to supply the demands there as in the  
 "arteries."

And according to Carson's theory the arteries



should be equally empty after death occasioned by lightning as when occasioned by puncturing the spinal marrow; for the violence & activity of the veins and arteries, to which he attributes this phenomenon, is as he acknowledges a property of texture and of crass must continue long as that texture remains perfect. — But the arteries are not empty when death has been occasioned by lightning. The reason for which will be offered hereafter.

What I mean that the emptiness of the arteries after death is caused by a vacuum existing in the chest,

do not deny that venous circulation during Life is promoted by the vacuum, caused by the expansion of the chest in inspiration; this has been proved by Barry. — But still I cannot coincide with him that this vacuum is the chief cause, — not remove the blood from the great veins in the neighbourhood of the heart, which seems disturbed during inspiration.

I do not suppose that blood would not flow





from the lower part after a long time had been passed  
 on is near the heart, & functions in some way  
 nature as in some other. Dr. Brown's hypothesis  
 is not yet. But the liver does live as has been  
 before shown.

I have come now to the question of the action  
 of the heart and some other, namely. That nervous  
 stimulation is owing, mainly to the action of the  
 capillary vessels: an action the existence of which  
 has been much questioned; and from the im-  
 portance of the matter, difficult to be discovered by  
 the eye; therefore we are forced in some measure  
 to reason from analogy.

That capillary vessels are endowed with a  
 power of propelling fluids, seems evident, from the  
 economy of Plants and Trees, they have no heart,  
 yet a fluid is taken up by the minute capillaries  
 of the roots, is conveyed a considerable height to



under the necessary change in the source, and  
from thence is conveyed, and deposited in other  
parts for the growth, for the separation of injuria.

But confining myself to the animal  
economy, and passing over the abdominal cir-  
culation, where the blood distributed through  
the arteries to the different viscera, passes thro'  
through minute vessels to a large trunk, is  
conveyed through it, and minutely distributed in  
the substance of the Liver, then once more is collected  
into large vessels before it reaches the vena Cava; in  
its way to the heart.

But passing over the abdominal circulation, we  
have an instance in the Statistics of a tree propelling  
its own contents, even when they are nearly solid, by  
contractions, obvious to the sight. - Certain in-  
termediate Animals also have no heart, their blood is  
circulated by the action of the vessels themselves.  
And it is to the same kind of action we must



affluent the *venous* blood, from the different  
portray glands as the liver, the salivary glands  
&c.

But in the lymphatics and lactals  
the analogy is more striking; for there a fluid is  
taken up, conveyed by their own contractions, a greater  
or less distance, notwithstanding the obstructions  
from the convolutions in the lymphatic glands,  
and eventually is emptied into the left subclavian  
vein.

And this action of the absorption continues  
even after the contractions of the heart has ceased;  
as may be seen by retaining the pressure of our  
venous blood a short time after having been bled.

Substances also have been injected into animals,  
after being thus apparently to death, and were taken  
up by the absorbents, and discovered in other parts  
of the animal body. Davis's experiments do not prove,  
as he thinks, that absorption depends upon atmos-  
pheric pressure; they only prove that the force by  
which lymph is propelled, is inferior in degree to



the pressure of the atmosphere, and that when put  
in opposition to the obstacles, the motion of the fluids  
in these vessels is checked, or its course reversed.

That Capillary vessels possess a force of contrac-  
tion, is supported by the following extracts.

Instances occur, when from passions of the mind,  
"from a sudden great weakness, or blood-letting, or even  
"vomiting, the blood has retroceded from the smaller  
"into the larger arteries. And in like manner, from  
"an obstruction being formed in the pleural branches  
"above the valves, the blood has been known to  
"retire into the extreme branches." Haller page 31

Speaking of the blood in the Capillaries Richer  
says "In the ordinary state, it moves generally in  
"an uniform manner, from the arteries towards the  
"veins: but at every instant, it may find cause  
"of irregular oscillations in its numerous anasto-  
"moses: hence as we have seen the necessity of  
"these anastomoses. These irregular oscillations





"in the motion of the blood in the capillary system  
 "can be seen with a microscope, Haller, Spallanzani  
 "and others, saw them a hundred times. Others  
 "saw the Globules advance, recede, move in many  
 "different directions, in animals with red and cold  
 "blood, when they irritated the mesentery, or any other  
 "transparent part." General Anatomy, vol. 2. page 37

If then the blood can advance or recede  
 from a given point, by irritating that point, there  
 must be a power located there by which the blood  
 can be moved.

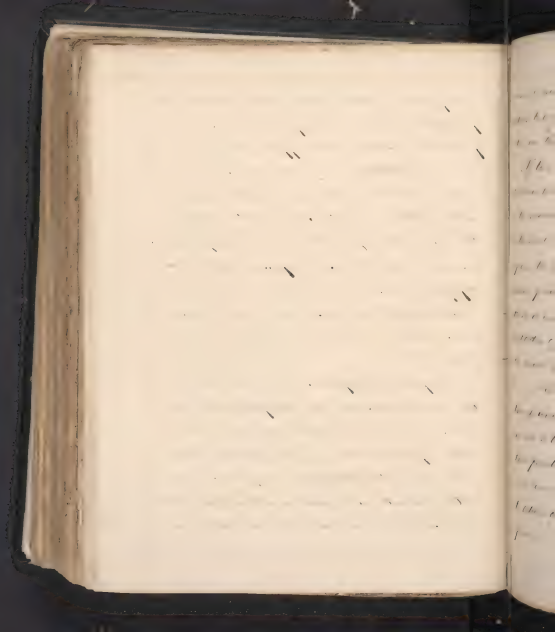
The power assisting venous circulation, namely,  
 the Elasticity of the arteries, and Muscular action  
 no doubt have some effect; but that elasticity is  
 not the cause of their vacuities is evident, for though  
 empty that elasticity prevents their particles from  
 coming in contact, hence they retain their caliber  
 after death. It is the action of the Muscles in =



is supposed to consist, in the blood circulating in a  
 great number of small and in one particular vessel. The  
 first arguments advanced in support of the effect of  
 numerous contractions namely, the numerous passages  
 made in it in a certain time, is not so strong as it  
 first seems to be, for the smallness of the lumen of  
 the vessels the drag water gives on its passage  
 and even blood must seek a passage through the  
 superficial veins.

But it is the only cause I can imagine of after  
 action without which nervous contraction cannot  
 be done.

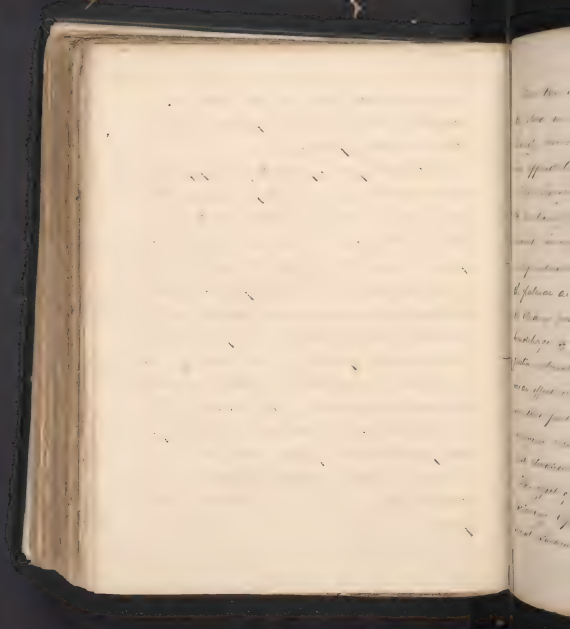
In speaking of capillaries, I do not say whether  
 there be a distinct set of vessels interposed between the  
 arteries and veins; or whether contractions exist only  
 in the capillaries or the small ramifications of arteries  
 performing functions attributed to capillaries; or  
 whether contraction also exists in arteries of somewhat  
 large size: but according to John Hunter it



does not exist in the arteries & in the middle time  
exists to an extent. But the explanation is not  
still not the true explanation.

If then the capillaries possess the power of propelling  
the blood into the veins; and if this power is lost  
of the capillaries, it is not true that the action  
of the heart has ceased. It is not sufficient to  
explain the cause of the death of the arteries of the  
death, provided, then, to some other power, to which  
the blood remains in the arteries after the last  
contraction of the left ventricle can be provided to  
the mouth of the capillaries for them to exit upon it.

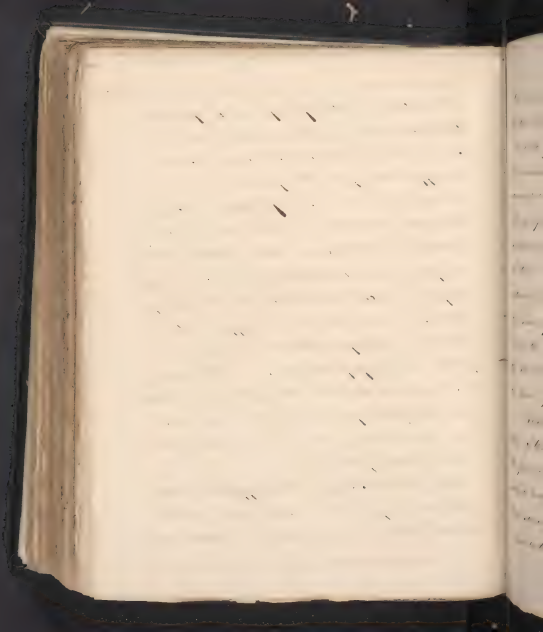
The blood is in the heart for there is no medium  
through which it can exit. It has ceased. It  
can exit to the arteries of the arteries, but this keeps  
them from the arteries, putting them in a  
position to their arteries, for there is no vessel  
to arteries of any size, or is inferior to the arteries  
power.



But there is another principle which operates on the blood in common with all other matter, viz. Gravity, but which so far as I know has never been applied to explain this phenomenon.

I had thought instances to be found in the action of the heart, even in the living body is evident; hence an inflamed extremity is directed to be kept elevated, and hence also in wounds of the palmar arch, where it is difficult to take up the bleeding vessel, the effect in stopping the hemorrhage, by keeping the arm raised to a position almost perpendicular. That gravity has an effect on the blood after death is evident, from that part upon which a dead body has been lying, becoming much injected, while the most elevated part is not.

This effect of Gravity is also supported by the following Experiments. 'After having killed several Salamanders by electricity in order that





The next morning we passed the bridge over the  
 the head. In fact in the morning we were  
 was instantly precipitated to the lower position,  
 and seemed to be in a situation open to the  
 cannot be a horizontal position. The first  
 stage of the head of the river the  
 volcanic and extended into the south of  
 the last river. I changed the position of the  
 altitude. The volcanic rocks were situated  
 to the same phenomenon as the one on the  
 above the effect of the rocks, but the position in  
 the small basins seemed to be little influenced by  
 the low, flatness on the southern side.

Just was the position of the two mountains  
 within of their eggs two days after the eruption that  
 the first of the two could not be sent any to the  
 without being favourable to the other. What the  
 first started moved on the first of the series  
 it had to the second a rapid and long run.



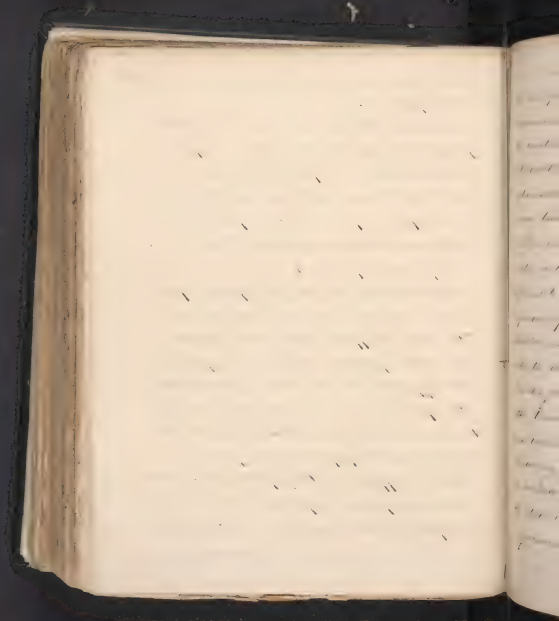
25  
"Powers" page 354.

"The blood of all animals is concerned with the principle of gravity, it is heavier than lymph." Note and whether be the position of the organs in a dead body, it accumulates to its own weight in the most dependant parts. the same phenomena was observed by Haller in Moribund Stages.

Spallanzani page 384

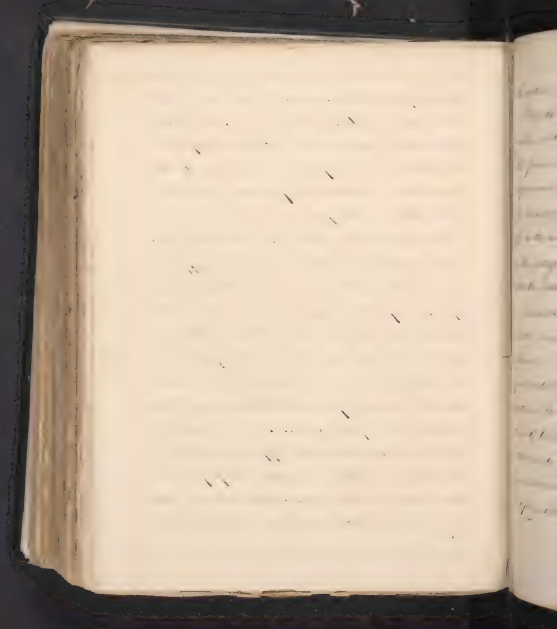
It seems to result from the most dependant parts of a dead body remains injected. If the circulation of the blood after apparent death, is owing to the action of the capillaries. This seems to be explained by the supposition, that the organ's life and action of the capillaries has become so far exhausted, before the blood has ceased flowing to their mouths, that they are unable to propel the last portions.

It we may suppose that the proportion transmitted by the most dependant capillaries is too great for the capacity of the corresponding veins: consequently



the most perfect, shall most accurately at the  
commencement of these times. And further,  
the injection or dark colour of the most dependent  
parts of the body, is owing partly, even as we see to the  
obstruction of blood, or its pervasion into the  
venous system of the parts.

From what has been said, I conclude, after the  
action of the left ventricle has ceased, appears  
sufficient to cause the blood to flow to the most  
dependent parts: where hence; from the aorta,  
situated nearly in the centre of the body, through  
either the anterior, the lateral, or the posterior  
branches, given off from that trunk or from  
other trunks, to be presented to the mouths of the  
most inferior capillary vessels; where, instantly  
maintaining themselves after apparent death, they  
are enabled by their own action to propel on  
the blood into the venous system, causing the  
engorgement of the veins, and the return of



the arteries, that is not till after death.

But the force of blood is contained with the  
valves, till expiration, as we saw & explain  
the phenomenon that took place in Marini's  
experiment before related and in that made  
by myself. When the impulse of the heart was cut  
off in the one case by pressure, in the other, by a ligature  
the artery got the circulation, went on in the same  
till the arteries were entirely empty.

As the blood flows on with it, till just  
before the lightning, we must understand the above  
phenomenon. It has relation, & dependence in every  
part of the system, at the same instant; the action  
of the respiratory system simultaneously with  
that of the heart; hence the blood that was con-  
tained in the arteries at the moment of death,  
must remain there; and I found it to be the same,  
excepting what passed into the various tissues.

That has been well above indicated





from the subject. I wish to understand  
sufficiently well to describe, but the it is clear  
it is not possible to do so, for the  
Singer into the pulmonary veins, then into the  
left ventricle and contracts and from thence is  
sent by the impulse of the heart, and thus  
keeping up an incessant circulation till it  
is lost and when in the capillary vessels  
it is expended.

But this part of the subject has in the  
13th No. of the Journal of Foreign Medicine  
in a paper by Williams been a satisfactory ex-  
position of the nature and of the symptoms, one  
of which has already been stated and as this  
is in some measure distinct from the other part  
of the subject, I shall only mention the occasions  
at which he has arrived, namely.

1st. When it is obstructed in its passage  
through the lungs, or suspension of respiration,



"while its circulation through other parts of the  
"body continues

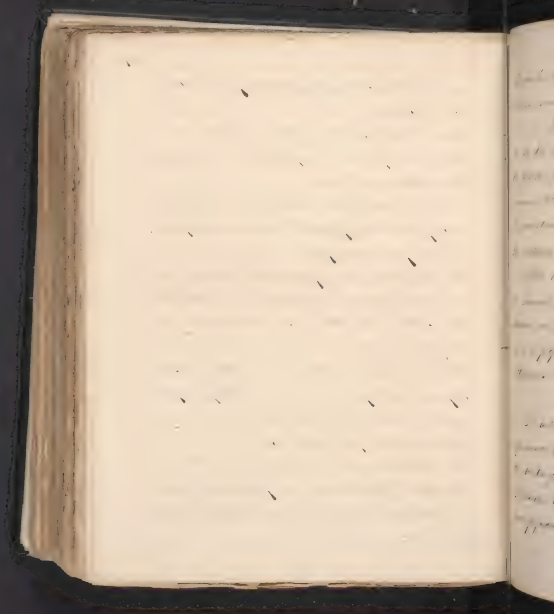
2<sup>nd</sup> "The obstruction of the blood in the  
"Lungs on suspension of respiration, is not the effect  
"of a mechanical cause.

3<sup>rd</sup>. "The obstruction of the blood in the lungs  
"on suspension of respiration arises from a deprivation  
"of pure atmospheric air.

4<sup>th</sup>. "The blood found 'post mortem' in the left  
"ventricle and aorta, is the remnant after the  
"last systole, and the subsequent relaxing of  
"the pulmonary veins.

5<sup>th</sup>. "The obstruction of the blood in the lungs on  
"suspension of respiration, is one of the principal  
"causes of the activity of the system, circulating  
"arterial blood, post mortem.

6<sup>th</sup>. "The immediate cause of the cessation of  
"the action of the heart, is a privation of its nat-  
"ural stimulus, arising from the obstruction of the blood in  
"the lungs.

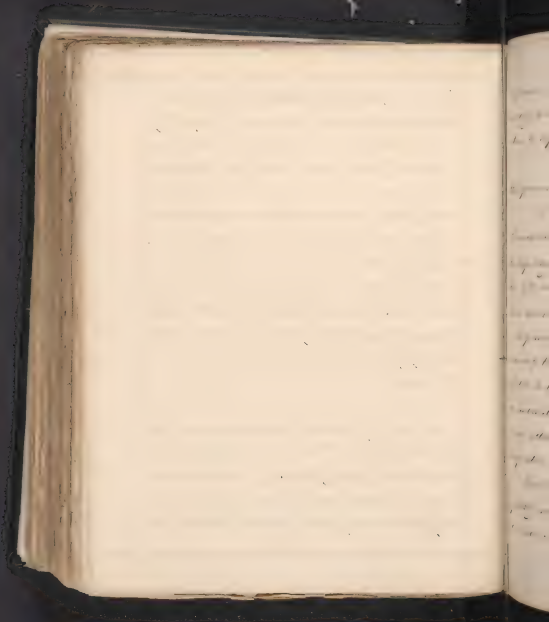


From the experiments in Station 1 come to the  
conclusion more similar to the one I have reported

When in the west division of the district  
we see the Capitoline of the city & we come to survey  
the blood from the great & are content to be for  
some time. Because a day is passed & nothing  
is seen. A collection which is made with great  
the various specimens.

under the first division the system of  
 the second system exists. The third list, the  
 various are completely correct, because the first  
 is in a proper state to affect the system.  
 Humans.

I will be pleased that materials thus so  
freely selected, have been extracted from  
the writings of other persons. On this account  
I consider them worthy of more notice, as they  
were prepared by persons of more or greater expe-



opinions in Divisions than myself, and particularly, as they were not performed with the intention of supporting views herein contained.

To conclude; I shall now of briefly the opinions I have endeavoured here to maintain.

During Life the blood is distributed throughout the arterial system, and presented to the capillary vessels, chiefly by the contractions of the left ventricle: yet is assisted by the elasticity and contractility of the arteries.

The passage back to the heart, again to go the round of the pulmonary circulation, is mainly effected by the action of the capillaries, though more or less assisted by certain collateral powers, as muscular action, the vacuum formed in the chest by inspiration &c.

But after apparent death, Gravity effects partially, what the heart did during Life, it causes the blood to continue in the arteries, after the last

of the eastern  
they are the  
of the paper  
relate to



contraction of the left ventricle, to flow to the most  
 dependent capillaries, to be by them propelled  
 into the venous system.

Thus on the one hand causing the vacuity  
 of the arteries after death; while on the other,  
 they are prevented from being again filled,  
 by the capillaries of the Lungs refusing to cir-  
 -culate blood not changed by Respiration.

